CLAIMS

WE CLAIM:

1. An extreme repetition rate gas discharge laser system capable of operating at pulse repetition rates in excess of 3,000 pulses per second, said laser comprising:

A) a laser chamber containing a laser gas and having two elongated electrodes, defining a discharge region and having a gas flow path with a gradually increasing cross section downstream of said electrodes to permit recovery of a large percentage of static pressure drop occurring in the discharge region,

B) a tangential type fan for producing sufficient gas velocities of said laser gas in said discharge region to clear from said discharge region, following each pulse, substantially all discharge produced ions prior to a next pulse when operating at a repetition rate in the range of 4,000 pulses per second or greater,

C) a heat exchanger system capable of removing at least 16 kw of heat energy from said laser gas,

D) a pulse power system configured to provide electrical pulses to said electrodes sufficient to produce laser pulses at rates of about 4,000 pulses per second with precisely controlled pulse energies in the range of about 5 mJ, and

E) a laser beam measurement and control system capable of measuring pulse energy energy wavelength and bandwidth of energy pulses or substantially every pulse with feedback control of pulse energy and wavelength.

2. A laser as in Claim 1 wherein said discharge laser system is a KrF excimer laser system and the laser gas is comprised of krypton, fluorine and neon.

3. A laser as in Claim 2 and wherein said chamber also comprises a vane structure upstream of said discharge region for normalizing gas velocity upstream of said discharge region.

4. A laser as in Claim 1 wherein said fan comprises a shaft driven by two brushless DC motors.

5. A laser as in Claim 4 wherein said motors are water cooled motors.

6. A laser as in Claim 4 wherein each of said motors comprise a stator and each of said motors comprise a magnetic rotor contained in a pressure cup separating a said stator from said laser gas.

7. A laser as in Claim 4 wherein said tangential fan comprise a blade structure machined from said aluminum stock.

8. A laser as in Claim 7 wherein said blade structure has an outside diameter of about five inches.

9. A laser as in Claim 4 wherein said motors are sensorless motors and further comprising a master motor controller for controlling one of said motors and a slave motor controiler for controlling the other motor.

10. A laser as in Claim 1 wherein said finned heat exchanger system is water cooled.

11. A laser as in Claim 10 wherein said heat exchanger system comprises at least four separate water cooled heat exchangers.

12. A laser as in Claim 10 wherein heat exchanger system comprises at least one heat exchanger having a tubular water flow passage wherein at least one turbulator is located in said path.

13. A laser as in Claim 11 wherein each of said four heat exchangers comprise a tubular water flow passage containing a turbulator.

14. A laser as in Claim 1 wherein said pulse power power system comprise water cooled electrical components.

15. A laser as in Claim 14 wherein at least one of said water cooled components is a component operated at high voltages in excess of 12,000 volts.

16. A laser as in Claim 15 wherein said high voltage is isolated from ground using an inductor through which cooling water flows.

17. A laser as in Claim 1 wherein said pulse power system comprises a resonant charging system to charge a charging capacitor to a precisely controlled voltage.

18. A laser as in Claim 17 wherein said resonance charging system comprises a De-Qing circuit.

19. A laser as in Claim 17 wherein said resonance charging system comprises a bleed circuit.

20. A laser as in Claim 17 wherein said resonant charging system comprises a De-Qing circuit and a bleed circuit.

21. A laser as in Claim 1 wherein said pulse power system comprises a charging system comprised of at least three power supplies arranged in parallel.

22. A laser as in Claim 1 wherein said laser beam measurement and control system comprises an etalon unit, a photo diode array, a programmable logic device, and optics to focus laser light from said etalon unit on to said photo diode array wherein said programmable logic device is programmed to analyze data from said photodiode array to determine locations on said photo diode array of etalon fringes.

23. A laser as in Claim 22 wherein said measurement an control system also comprises a microprocessor programmed to calculate wavelength and bandwidth from fringe data located by said programmable logic device.

24. A laser as in Claim 22 wherein said programmable logic device is programmed with an algorithm for calculating wavelength and bandwidth based on measurement of said fringes.

25. A laser as in Claim 24 wherein said programmable logic device is configured to make calculations of wavelength and bandwidth faster than 1/4,000 of a second.

26. A laser as in Claim 22 wherein said etalon unit comprises a defractive diffusing element.

27. A laser as in Claim 1 and further comprising a line narrowing unit comprising a tuning mirror driven at least in part by a PZT drive.

28. A laser as in Claim 27 wherein said tuning mirror is also driven in part by a stepper motor.

29. A laser as in Claim 27 and further comprising a pretuning means.

30. A laser as in Claim 27 and further comprising an active tuning means comprising a learning algorithm.

31. A laser as in Claim 27 and further comprising an adaptive feed forward algorithm.

32. A laser as in Claim 27 wherein said line narrowing unit comprises a grating defining a grating face and a purge means for forcing purge gas adjacent to said grating face.

33. A laser as in Claim 32 wherein said purge gas is nitrogen.

34. A laser as in Claim 32 wherein said purge gas is helium.

35. A laser as in Claim 1 and further comprising a nitrogen purge system comprising a nitrogen purge system comprising a nitrogen filter.

36. A laser as in Claim 1 and further comprising a nitrogen comprising a purge module comprising flow monitors said laser also comprising purge exhaust tubes for transporting exhaust purge gas from said laser.

37. A laser as in Claim 1 and further comprising a shutter unit comprising an electrically operated shutter and a power meter which can be positioned in a laser output beam path with a command signal.

38. A laser as in Claim 27 and further comprising a beam seal system providing a first beam seal between a first window of said chamber and line narrowing unit and a second beam seal between a second window of said chamber and an output coupler unit, each of said beam seals comprising a metal bellows.

39. A laser as in Claim 38 wherein each of said first and second beam seals are configured to permit easy replacement of said laser chamber.

40. A laser as in Claim 38 wherein each of said beam seals contain no elastomer, provide vibration isolation from said chamber, provide beam train isolation from atmospheric gases and permit unrestricted replacement of said laser chamber without disturbance of said LNP or said output coupler unit.

41. A laser as in Claim 1 wherein said measurement and control system comprises a primary beam splitter for splitting off a small percentage of output pulses from said laser, a second beam splitter for directing a portion of said small percentage to said pulse energy detector and a means isolating a volume bounded said primary beam splitter, said secondary beam splitter and a window of said pulse energy detector from other portions of said measurement and control system to define an isolated region.

42. A laser as in Claim 41 and further comprising a purge means for purging said isolated region with a purge gas.

43. A laser as in Claim 42 wherein said laser further comprises an output coupler unit and an output window unit said purge means being configured so that exhaust from said isolated region also purges said output coupler unit and said output window unit.

44. A laser as in Claim 1 wherein said chamber also comprises a current return having ribs with a generally rectangular cross section with a long direction in a direction of laser gas flow.

45. A laser as in Claim 1 wherein said chamber comprises an anode and dielectric spacers positioned on two sides of said anode to improve laser gas flow in regions between the two electrodes.

46. A laser as in Claim 1 wherein said pulse power system comprises a corona plate electrically connected to capacitors of a peaking capacitor bank and one of said electrodes by metal rods having lengths chosen to provide increased inductance.